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Shaft seal, in particular for an axial piston compressor

10 State of the art

is. A1

The invention relates to a subassembly consisting of a drive shaft, a housing with an aperture through which the drive shaft projects out of the housing, and an axial face seal comprising  
15 a sliding ring and a counter-ring, which creates a seal between the components drive shaft and housing. Expressed more generally, the invention relates to the sealing of shaft exit apertures by means of a seal consisting substantially of a sliding ring and a counter-ring against which the sliding ring  
20 is pressed in the axial direction of the shaft. The invention relates in particular to an axial piston compressor in which the housing is closed by a cover plate within which is disposed the exit aperture for the drive shaft as well as an axial face seal for the drive shaft. Such a compressor, with a subassembly  
25 of the kind described above, is known from the patent EP 0 864 787 A2.

In the following the invention is described with reference to an exemplary application for an axial piston compressor such as can be used in particular in an air-conditioning unit for motor  
30 vehicles. However, as explained at the outset, the invention can be employed in general for machines that comprise an axial face seal.

An axial piston compressor in a vehicle air conditioner serves to suck in a coolant from a heat-transfer compartment, in which  
35 it evaporates while taking up heat, and to raise its pressure

5 transfer compartment. The function of such axial piston  
compressors in such a coolant cycle is generally known, so that  
it need not be explained further here.

10 the drive shaft. The shaft seal of an open compressor is of particular significance because leakages of the circulating coolant, in particular a coolant leakage through the the shaft seal, has a negative effect on the operating behaviour of the air conditioner by reducing the amount of coolant contained.

15 Furthermore, it is prohibited to allow certain coolants to enter the atmosphere.

20 there, against which the seal must operate, these rings provide sufficiently reliable sealing at low cost. Such a radial shaft sealing ring is in general inserted into a recess on the outer surface of the housing.

CO<sub>2</sub> as a substitute for the coolant R134a, because CO<sub>2</sub> offers many advantages over R134a. However, the coolant CO<sub>2</sub> requires a higher pressure level than R134a, so that more technically demanding seals are needed. Therefore it is customary to use axial face seals, in which owing to the cooperation of sliding ring and counter-ring, which are pressed against one another, it is possible to obtain adequate sealing against the high pressure difference. The axial face seal, however, cannot be mounted on the outer surface of the housing, but rather must be disposed in the interior of the housing, for instance behind a

cover plate. Furthermore, the relative rotation between the sliding ring and the counter-ring generates so much frictional heat that a controlled dissipation of that heat seems desirable. However, in axial piston compressors for vehicle air conditioners no separate lubricant circulation is provided that could be used to carry away the frictional heat in the region of the sliding ring, nor does the mist of lubricant in the interior of the housing of the axial piston compressor suffice to dispose of the frictional heat produced.

10 The objective of the invention is thus to provide a shaft seal  
that can be mounted simply and economically and that enables  
good dissipation of the frictional heat that is generated.

### Advantages of the invention

In a subassembly in accordance with the invention, with the characteristics given in the characterizing part of Claim 1, because the counter-ring is no longer a separate part that must be inserted into the cover plate, less effort is required for installation. Because the counter-ring itself need no longer be so stable that it can be manipulated and mounted as a separate component, it can be made considerably less thick than conventional counter-rings, which for example must be pressed into a recess. The diminished thickness of the counter-ring offers two advantages. First, it reduces the length of the whole structure. Second, it improves the heat dissipation. That is, although such counter-rings are customarily made of material with extremely poor thermal conductivity, because the counter-ring is less thick it can adequately conduct heat away from the component into which it is integrated. The thermal conductivity is also improved in comparison with state-of-the-art constructions in that the counter-ring is now directly connected to the relevant component rather than being partially isolated therefrom, for instance by O-rings that must be pressed into place to serve as seals for the counter-ring according to the state of the art.

The above term "integrated" is used in the sense of this application firstly to designate a unit in which the counter-ring is non-removably connected to the component on which it is seated, and secondly to indicate that said component is so  
5 configured that the counter-ring is formed by a section of the component itself.

According to one embodiment of the invention the counter-ring can be glued, welded or soldered to the component that supports it. By this means, with little effort the desired integral and  
10 gas-tight connection between counter-ring and supporting component is achieved.

According to another embodiment the counter-ring is formed by a coating applied to the relevant component, for example by means of a CVD or PVD process. This allows the counter-ring to be  
15 made particularly thin, so that the axial length of the overall structure is very small. Another result is that the heat conduction from the counter-ring to the supporting component is optimized, because no insulating intermediate layers are present. Still another advantage is that a counter-ring can be  
20 obtained, the surface of which needs no further treatment.

The coating is preferably a ceramic layer. A counter-ring so formed is especially resistant to wear and tear. After the ceramic coating has been applied, it is preferably treated mechanically so as to produce the desired low degree of surface  
25 roughness.

The ceramic coating preferably consists of SiC. Tungsten carbide is also a suitable material. Then the sliding ring can be made of impregnated hard carbide, which has proved an advantageous pairing with respect to friction. With such a  
30 frictional pairing it is preferable for the material with the better thermal conductivity, in this case SiC (with a thermal conductivity of 125 W/mK), to be used for the counter-ring, which then because it is integrated with the supporting

component conducts the frictional heat produced in the axial face seal better than would be the case for a configuration in which the impregnated hard carbide (with a thermal conductivity of 25 W/mK) was responsible for conducting heat away from the housing.

According to a preferred embodiment of the invention the counter-ring is made in one piece with the housing, in which case the latter consists of aluminium or an aluminium alloy. Such a housing part can be especially well coated with a layer of tungsten carbide, because the temperature of the housing part during the coating process does not exceed 200°C. Layer thicknesses of 0.1 mm to 1 mm can be achieved. By mechanical finishing, for example polishing, a surface roughness Ra of 0.06 mm can be obtained. The hardness of such a layer is 75-80 HRC.

According to another embodiment of the invention it is provided that the counter-ring is an integral component of the housing, i.e. is produced by working the surface of the housing itself. A prerequisite is that the cover plate be made of a material suitable for creating a seal in cooperation with the sliding ring. The counter-ring is then formed by processing an annular region of the cover plate in such a way as to achieve the required smooth surface.

According to the preferred embodiment of the invention, the sliding ring is provided with a groove on its bearing surface that cooperates with the counter-ring. This groove acts as an oil pocket. This interruption in the bearing surface of the sliding ring in effect produces two bearing surfaces one after the other, which increases the efficiency of the seal. Alternatively, the counter-ring could be provided with a groove. It is also possible to make the bearing surface of the counter-ring convex or concave, so as to allow for deformations under the action of heat.

An axial piston compressor in accordance with the invention as described in Claim 14 offers the advantage that it is possible for the frictional heat that is generated to be especially well transferred from the counter-ring directly into the housing of the compressor. This reduces the warming of the axial face seal, which results in less thermal and mechanical distortion and deformation. Furthermore, installation is simplified because the counter-ring does not need to be separately inserted into the cover plate. Here the term "cover plate" is understood to mean the part of the housing that is provided with the exit opening for the drive shaft; depending on the structural design and nature of mounting of the compressor, this part can also be the central part of the housing. Economical advantages are also obtained, because in comparison to the state of the art two parts are eliminated, namely the counter-ring as a separate component and the O-ring that would otherwise be needed as a seal for the counter-ring. If leakage should occur in the region of the axial face seal, a new counter-ring can be installed with little effort simply by exchanging the cover plate.

Advantageous embodiments of the invention will be evident from the subordinate claims.

#### Drawings

In the following the invention is described with reference to the attached drawings, wherein

- Figure 1 shows an axial piston compressor according to the state of the art, in a schematic sectional view;
- Figure 2 shows on a larger scale a part of an axial piston compressor in accordance with the invention, corresponding to the region II in Figure 1.

# Description of the exemplary embodiment

In Figure 1 an axial piston compressor according to the state of the art is shown. It contains a housing 10 in which a drive shaft 12 is rotatably mounted. Seated on the drive shaft is a wobble plate 14 that cooperates with pistons 16. In Figure 1 only a single piston is visible; in fact, as many as seven pistons are provided, each of which is translationally displaceable within a cylinder. In the region where the drive shaft 12 emerges from the housing 10 there is disposed a cover plate 18 provided with an exit aperture 19 through which the drive shaft 12 passes out of the housing 10. Pressed into the cover plate is a counter-ring 20 with an O-ring 21. A sliding ring 22 makes contact with the counter-ring 20 and is pressed against the counter-ring by a spring 24. By this means an axial face seal is formed, which seals off the housing from the exterior space in the region of the exit aperture 19.

In Figure 2 the configuration of the seal in the region where the drive shaft 12 passes through the cover plate is shown for an axial piston compressor in accordance with the invention. The counter-ring 20 is made integral with the cover plate 18, being formed by a thin layer of SiC. Apposed to the counter-ring 20 is the sliding ring 22, which can consist for example of impregnated hard carbide and is provided with a V-shaped groove 26 in its bearing surface.

The embodiment in accordance with the invention also employs a spring 24, which presses the sliding ring 22 against the counter-ring 20. The sliding ring is disposed in the interior of a spring holder 28, which together with a capture plate 30 ensures that a self-contained subassembly is formed. Between the sliding ring 22 and the drive shaft 12 an O-ring 32 is disposed; this ensures that the sliding ring 22 cannot rotate with respect to the drive shaft 12, so that rotation of the drive shaft causes a relative rotation between the sliding ring 22 and the counter-ring 20.

It is in principle also possible to reverse the arrangement of sliding ring and counter-ring: the counter-ring could be constructed in one piece with the drive shaft, for example on a shoulder of the shaft, and the sliding ring could be disposed  
5 on the housing, with a force applied to press it against the counter-ring.



List of reference numerals

- 10: Housing
- 12: Drive shaft
- 14: Wobble plate
- 5 16: Piston
- 18: Cover plate
- 19: Exit aperture
- 20: Counter-ring
- 21: O-ring
- 10 22: Sliding ring
- 24: Spring
- 26: Groove
- 28: Spring holder
- 30: Capture plate
- 15 32: O-ring